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MATHEMATICS.—*A mathematical note on the annealing of glass.*[1]

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In a recent paper[2] Adams and Williamson have discussed at some length the annealing of glass. It is not the object of the present note to revise the deductions made from the experimental data but rather to show how the mathematical treatment of the equations representing these deductions may be made more rigorous. The immediate practical aim is to discover whether this course will indicate a possible procedure by which the time spent in the annealing process can be materially shortened. We shall anticipate by saying that this is found to be the case and a fifteen per cent reduction of time can be made. A future communication will give detailed schedules for various types of glass on this new basis.

The problem to be solved may be stated as follows. A block of glass is found to be in a condition of internal strain. By holding it at a temperature somewhat below the softening point the strain may be removed at a rate depending on that temperature. Further strain will be added during the cooling process due to temperature differences set up in cooling. It is required to find at what temperature to hold the glass, how long to hold it at that temperature (or, what is the same thing, to what degree of completeness to remove the strain) and how rapidly to cool at every point in the course of cooling so that the least possible time be taken consistent with the final strain being inside the allowable limits.

The notation used is that of the paper already cited.

θ = temperature in degrees Centigrade.

θ_0 = temperature at which glass is held to remove strain.

[1] Received November 15, 1921.

[2] L. H. ADAMS and E. D. WILLIAMSON. Journ. Franklin Inst. 190: 597–631; 835–870. 1920.

h = cooling rate in degrees per minute.
h_o = initial cooling rate at θ_o.
N = total strain allowable in optical units.
ΔN_a = strain left in glass after holding at θ_o.
ΔN_c = strain introduced by temperature differences in cooling.
t_a = annealing time = time the glass is held at θ_o.
t_c = time spent in cooling.
A = annealing constant as found in table 3, *op. cit.*
A_o = value of A at θ_o.
c = constant, depending on the type of glass, defined by equation (10), page 841, *op. cit.*

The last part of the problem will be solved first. That is, if the glass has been held at θ_o till the strain is reduced to ΔN_a how must it be cooled so that t_c may be a minimum consistent with the final strain being N, or in other words, having $\Delta N_c = N - \Delta N_a$?

$$t_c = -\int_{\theta_o}^{\theta} \frac{d\theta}{h} \text{ and } N - \Delta N_a = \Delta N_c = -c^2 \int_{\theta_o}^{\theta} A \frac{\left(h - \frac{\Delta N_a}{c}\right)^2}{h} d\theta$$

the latter being the integral of equation 12 in the previous paper which depends on the experimental results set forth there. Applying the calculus of variations to find h as a function of θ yields

$$\text{const.} \frac{d}{dh}\left(\frac{1}{h}\right) - A \frac{d}{dh} \frac{\left(h - \frac{\Delta N_a}{c}\right)^2}{h} = 0$$

$$\text{or } A\left(h^2 - \frac{\Delta N_a^2}{c^2}\right) = \text{constant} = A_o\left(h_o^2 - \frac{\Delta N_a^2}{c^2}\right). \qquad (1)$$

Now it is shown in the previous paper that

$$A = A_o . 2^{\frac{\theta - \theta_o}{10}}.$$

$$\text{Therefore } \left(h^2 - \frac{\Delta N_a^2}{c^2}\right) = \left(h_o^2 - \frac{\Delta N_a^2}{c^2}\right) 2^{\frac{\theta_o - \theta}{10}}.$$

Equation (1) shows how the rate may be increased as the temperature drops, and h_o, the initial rate, may be found by the condition that $\Delta N_c = N - \Delta N_a$. The time consumed will then be the minimum

possible under the conditions of the problem. An example of how the cooling rate changes is found in table 1.

The problem may now be restated. t_a is a function of A_o and ΔN_a, and t_c can also be expressed in terms of these by means of equation (1) and the proper value of h_o, that is, provided the necessary integrations can be carried out. Can values of A_o and ΔN_a be chosen so that $(t_a + t_c)$ may be a minimum?

$$\text{Now } t_c = -\int_{\theta_o}^{\theta} \frac{d\theta}{h}$$

$$\text{but } h^2 - \frac{\Delta N_a^2}{c^2} = \left(h_o^2 - \frac{\Delta N_a^2}{c^2}\right) 2^{\frac{\theta_o - \theta}{10}}.$$

From the latter, taking the logarithm of each side and differentiating

$$d\theta = -\frac{20\, h dh}{\left(h^2 - \frac{\Delta N_a^2}{c^2}\right) \ln 2}.$$

$$\text{Therefore } t_c = \frac{20}{\ln 2} \int_{h_o}^{h} \frac{dh}{h^2 - \frac{\Delta N_a^2}{c^2}} = \frac{10\, c}{\Delta N_a \ln 2} \left[\ln \frac{h - \frac{\Delta N_a}{c}}{h + \frac{\Delta N_a}{c}} \right]_{h}^{h_o}.$$

In actual practice the cooling proceeds over a range of several hundred degrees. By this time h is large compared with $\Delta N_a/c$ so that the upper limit of the integral may be taken as containing ln 1 and hence is zero.

The result therefore is

$$t_c = \frac{10c}{\Delta N_a \ln 2} \ln \frac{h_o + \frac{N_a}{c}}{h_o - \frac{N_a}{c}}$$

in which h_o has yet to be determined by the condition

$$N - \Delta N_a = -c^2 \int_{\theta_0}^{\theta} A \frac{\left(h - \frac{\Delta N_a}{c}\right)^2}{h} \, d\theta.$$

Making the same substitution as before for $d\theta$, and remembering that $A = A_0 \, 2_0^{\frac{\theta - \theta_0}{10}}$, the integration is simple, and yields

$$N - \Delta N_a = \frac{20 \; c^2 A_0 \left(h_0 - \frac{\Delta N_a}{c}\right)}{\ln 2}.$$

Taking the value of h_0 from this and substituting in the value of t_c, we get

$$t_c = \frac{10 \; c}{\Delta N_a \ln 2} \ln \left[\frac{(N - \Delta N_a) \ln 2 + 40 \; cA_0 \; \Delta N_a}{(N - \Delta N_a) \ln 2}\right].$$

We shall assume that the original strain in the glass is so large that its reciprocal is negligible compared with $\frac{1}{\Delta N_a}$. Then by equation (7*c*) in the previous communication

$$t_a = \frac{1}{A_0 \, \Delta N_a}.$$

Therefore $t_a + t_c = \frac{1}{A_0 \, \Delta N_a} + \frac{10c}{\Delta N_a \ln 2} \ln \left[\frac{(N - \Delta N_a) \ln 2 + 40 \, cA_0 \; \Delta N_a}{(N - \Delta N_a) \ln 2}\right].$

Partial differentiation with respect to A_0 and ΔN_a yields two equations as conditions for $(t_a + t_c)$ having a minimum value. After a little simplification these take the form

$$580 \; \Delta N_a c^2 A_0^{\,2} = (N - \Delta N_a) \ln 2 + 40 \; \Delta N_a c A_0$$

$$\text{and } \ln \left[\frac{(N - \Delta N_a) \ln 2 + 40 \; \Delta N_a c A_0}{(N - \Delta N_a) \ln 2}\right] = \frac{\Delta N_a \ln 2}{(N - \Delta N_a) \, 10 \, cA_0}.$$

The form of the second equation makes it necessary to use an approxi-

mate solution. A sufficiently close one is

$$cA_o = 0.075$$
$$N_a = 0.725\,N.$$

If, then, we know c, the constant which depends on the elastic properties of the glass, and have a table like table 3 in the older paper showing the values of A for various temperatures, the required problem is completely solved and one can say definitely that the glass must be held a certain temperature for a certain time and be cooled at a predetermined rate at every instant of its cooling in order that the necessary conditions may be fulfilled.

The total time necessary for the process is

$$\frac{c}{0.075 \times 0.725\,N} + \frac{c}{0.075 \times 0.275\,N} = 66.9\frac{c}{N}.$$

In computing this the value of t_c was simplified by means of the second conditional equation.

As an illustration the case of a slab of plate glass 2 cm. thick will be treated. This is the same example that was previously used to illustrate four different procedures. In this case c is about 13 and we shall suppose $N=5$ as in the older work. Then $A_o = \frac{0.075}{13} =$ 0.0058, and reference to figure 12, in the original, places this at about 520° C., which is 6° higher than in the fastest previous schedule. ΔN_a will be equal to 3.625. The glass must be held at this temperature for $\frac{1}{0.0058 \times 3.625} = 47.6$ minutes, and the total time will be 174 minutes or a little better than 15 per cent less than in the best previous schedule.

The initial rate of cooling $h_o = \frac{(N - \Delta N_a)\ln 2 + 20\,cA_o\,\Delta N_a}{20\,c^2 A_o}$

= (in this case) 0.33° per minute. The table shows how that rate increases as the temperature drops.

We have been asked recently how long a time is necessary for annealing a sheet of glass 25 feet in diameter and 2 feet thick. If the glass be one for which the constants are known the question can be easily answered. Suppose the glass is of the same type as in the previous example, then c will be approximately 13×30^2. The final

allowable strain in this particular case was given as $N=20$. We then find

$$t_a = \frac{13 \times 30^2}{0.075 \times 0.725 \times 20} \text{ minutes} = 10760 \text{ minutes} = 7.5 \text{ days.}$$

$$\text{Total time} = 66.9 \times \frac{13 \times 30^2}{20} \text{ minutes} = 39140 \text{ minutes} = 27.2 \text{ days.}$$

$$A_o = \frac{0.075}{13 \times 30^2} = 0.0000064.$$

Therefore $\theta_o = 419°$ C. (see table 5 and equation (8), *op. cit.*), and $h_o = 0.33 \times \frac{4}{30^2} \times 1440°$ C. per day $= 2.11°$ C. per day. The glass should therefore be held at 419° C. for seven and one-half days and then cooled, the initial cooling rate being a little over 2° per day and increasing as in the table.

TABLE 1.—SCHEDULE ACCORDING TO WHICH THE COOLING RATE SHOULD BE INCREASED

Initial rate	1.00
Rate after 10° cooling	1.12
Rate after 20° cooling	1.36
Rate after 30° cooling	1.73
Rate after 40° cooling	2.30
Rate after 50° cooling	3.15
Rate after 60° cooling	4.36
Rate after 70° cooling	6.12
Rate after 80° cooling	8.60
Rate after 90° cooling	12.15
Rate after 100° cooling*	17.14

* In the later part of the range the cooling-rate practically doubles every 20°.

SUMMARY

From the equations representing the results of experimental work previously described, the most favorable conditions for annealing a given piece of glass can be deduced. Formulas are found which, used in conjunction with tables of the elastic and annealing constants of the glass, show at what temperature to hold the glass, how long to hold it at that temperature, and how rapidly to cool it in order to get any degree of fineness of annealing in the least possible time. Examples are solved to illustrate the processes.

MINERALOGY.—*Gillespite, a new mineral.*[1] WALDEMAR T. SCHALLER, U. S. Geological Survey.

A small rock specimen collected from a moraine near his claim near the head of Dry Delta, Alaska range (about 100 miles S. E. of Fairbanks), Alaska, by Mr. Frank Gillespie (after whom the mineral is named) of Richardson, Alaska, was brought to the Chemical Laboratory of the U. S. Geological Survey by Dr. Philip S. Smith of the Survey.

The rock specimen is composed chiefly of a mica-like mineral (gillespite), with a striking red color, which could not be identified by simple tests. By chemical analysis the mineral proved to be a silicate of ferrous iron and barium with the composition $Fe''BaSi_4O_{10}$. Two other minerals, a grayish green diopside and a white barium feldspar, with the red gillespite, compose the rock. Several other minerals are seen in thin sections but only in very small quantities. The mode of occurrence of the rock is not known but it suggests contact metamorphism with the development of abundant barium minerals.

The red gillespite forms thick scaly masses from one to five millimeters across and nearly as thick. The rock mass is compact and although no crystal faces except the basal plane could be detected, thin sections of the rock suggest an occasional terminal plane on a gillespite. The mineral does not scale off like mica but the basal cleavage is very well developed. The physical properties are: brittle, H. = 4, sp. gr. = 3.33. Luster vitreous, color red, streak pink. The color is close to Ridgway's[2] "Pomegranate Purple," Pl. XII, hue no. 71, tone *i*, and to "Spinel Red," Pl. XXVI, hue no. 71, tone *b*. The powder approaches "Geranium Pink," Pl. I, hue no. 3, tone *d*. Translucent. Optically uniaxial, negative, birefringence very low, strongly pleochroic. Refractive indices: ϵ (rose red) 1.619, ω (pale pink to nearly colorless) 1.621.

In the blow-pipe flame, gillespite fuses easily and quietly to a black non-magnetic globule. Heated in a closed tube, it darkens and assumes a deep violet color, the original red color being regained on cooling. Readily decomposed by HCl, without gelatinization, the mineral flakes being changed to glistening flakes of silica which retain the shape of the original mineral. These residues of silica are doubly

[1] Received October 24, 1921. Published by permission of the Director, U. S. Geological Survey.

[2] R. RIDGWAY, *Color standards and color nomenclature.* Washington, D. C., 1912.

refracting and are being further studied. Sulphuric acid decomposes the mineral with separation of silica and formation of barium sulphate.

An analysis of a hand-picked sample of gillespite, with only a few per cent of other mineral present gave the following results:

Analysis of gillespite		Ratios	
SiO_2	50.08	0.831	4.034 or 4×1.01
FeO	14.60	0.203	0.985 or 1×0.99
BaO	31.02	0.202	0.980 or 1×0.98
Al_2O_3	0.34		
Fe_2O_3	0.56	0.008	.....
Mn_2O_3	0.14		
Insoluble	2.20		
Water[a]	0.82		
	99.76		

[a] Water determined by "ignition loss" corrected for (assumed) oxidation of FeO to Fe_2O_3. Selected pure fragments of gillespite give no water when heated in a closed tube.

The formula of gillespite is $FeO.BaO.4SiO_2$ or $Fe''BaSi_4O_{10}$. If the ferrous iron and the barium be considered as isomorphously replacing each other, then the formula simplifies to $(Fe'',Ba)Si_2O_5$. There is, however, no evidence for such isomorphous replacement and as the ratios of ferrous iron and barium in the analysis are sharply 1:1, the formula $Fe''BaSi_4O_{10}$ is to be preferred.

The presence of the small quantity of manganese was definitely determined and it is assumed to be present in the strongly chromatic manganic state; the combination of such manganic manganese with possibly a small quantity of ferric iron yielding the deep red color of the mineral. Titanium is not present.

There does not seem to be any group of minerals to which gillespite is closely related, considering its properties and chemical composition.

ICHTHYOLOGY.—*Notice of a spiral valve in the Teleostean fish* Argentina silus, *with a discussion of some skeletal and other characters.*[1] WILLIAM C. KENDALL and DONALD R. CRAWFORD, U. S. Bureau of Fisheries.

INTRODUCTION

Distribution.—Argentina silus is found rather infrequently along the Atlantic coast of the United States, although it is not rare off the coast of Norway. The flesh is edible, but *Argentina silus* is not taken in sufficient quantities to be of economic importance.

[1] Received November 19, 1921.

The following are the only records known to us of the capture of the species on the Atlantic coast of the United States. A specimen was found in the stomach of *Physis tenuis* taken off Sable Island in 200 fathoms, which is recorded by Goode and Bean as type number U. S. N. M. 21624, "*Argentina syrtensium*" (Proc. U. S. Nat. Mus., 1878, page 261), and in Oceanic Ichthyology, page 52, as *Argentina silus*.

In July, 1891, a specimen 18 inches long (U. S. N. M. No. 43708) was caught by a boy with a hook and line in the harbor of Belfast, Maine. (Goode and Bean, Oceanic Ichthyology, page 52.) Another, No. 37801, 15 inches (381.0 mm.) long, was taken at Biddeford Pool, Maine (loc. cit.), March 19, 1886.

In 1904, Mr. John R. Neal, of Boston, Mass., sent in for identification by the U. S. Bureau of Fisheries a specimen about 13.5 inches (342.9 mm.) long, taken by a fisherman probably on Georges Bank, September 19 of that year. Another specimen in the collection of the U. S. National Museum, No. 55636, was found at Fletchers Neck, near Ocean Beach, Maine, May 7, 1906.

In the collection of Mr. W. W. Welsh, of the U. S. Bureau of Fisheries, are two young specimens collected on the coast of Maine as follows: 1 specimen 49 mm. long, August 14, 1912, in a closing net at a depth of 35 fathoms, 33 miles north from Mt. Desert Rock. Another, 38 mm. long, August 13, 1913, 25 miles N. E. from Petit Manan light, somewhere above a depth of 110 fathoms.

In December, 1912, a specimen about 15 inches (381.0 mm.) long was found on Hampton Beach, N. J., and was sent to the Bureau of Fisheries by Mr. B. F. Smart, of the U. S. Life Saving Service.

Early in January, 1914, a specimen nearly 14 inches (355.6 mm.) long was found at Hampton Beach and sent in to the Bureau. These latter specimens form the basis for the observations comprised in this paper.

Habits.—Little is known of the habits of this fish. It has been caught in the north Atlantic from Iceland to the coast of Ireland,[2] in rather deep water. The eggs[3] of *Argentina silus* are 3.0 to 3.5 mm. in diameter and are bathypelagic; that is, they float far below the surface where they have been taken in 50 to over 1,000 meters of water.

[2] JOHS. SCHMIDT, *On the Larvae and Post-larval Development of the Argentines* (Argentina silus *Ascan.* and Argentina sphyraena *Linne*). Meddelelser Fra Kommissionenfor Hovunders gelser, Sene Fiskeri, Kobenhavn. **2:** 1–20. Nov. 4, 1906.

[3] *Op. cit.*

It is known that this fish may be caught on bait of mussels (*Mytilus*, according to Nilsson), or on pieces of herring.[4] According to Holt,[5] one specimen caught off the coast of Ireland had in its stomach remains of shrimps and copepods, one of which was identified as *Calamus finmarchichus*, which is known to inhabit the bottom.

VISCERAL ANATOMY

Alimentary Tract and Spiral Valve

The presence of a spiral valve is of considerable interest since up to the present time but one living adult Teleost was known to possess a true spiral valve in the intestine.

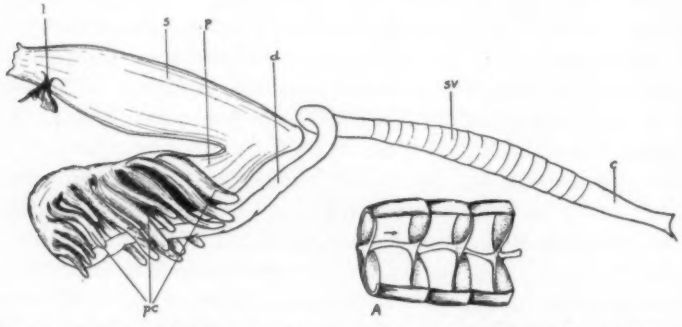

Fig. 1. Stomach and intestine of *Argentina silus* × 2/3.—*l*, attachment of liver; *s*, cardiac limb of stomach; *p*, pyloric limb of stomach; *pc*, pyloric caeca; *d*, duodenum; *sv*, spiral valve; *c*, rectum. *A*, small portion of spiral valve, with part of the outer wall removed to show internal structure, semi-diagrammatic, × 6.

In *Argentina silus* it has no doubt been overlooked partly because its presence hitherto was unsuspected and also because of the comparatively few specimens available for study. It is not known from the limited material examined whether or not this structure is as variable in different individuals of *Argentina silus* as it is known to be in different individuals of some species of rays and sharks. The two specimens at hand were essentially the same, each showing a true spiral cavity wound around a small central canal. Thus, the

[4] F. A. SMITT, *Scandinavian Fishes*, ed. 2, 2: 916. Stockholm, 1895.

[5] W. L. HOLT, *The Great Silver Smelt, Argentina silus*, Nilss. *An addition to the List of British Fishes.* Journal of the Marine Biological Association of the United Kingdom. N. S. 5: 341–342. 1897–99.

spiral valve in *Argentina silus* is fully as well developed as it is in the ganoids, among which it is very well developed in *Polypterus* and the Sturgeon, but vestigeal in *Lepidosteous* and *Amia* (*Amiatus*).[6]

It is generally believed that the spiral valve is absent in the more specialized Teleostei with the possible exceptions of *Chirocentrus* and possibly some *Salmonidae*. In making the latter exception reference is made to Rathke's work published in 1824.

In discussing the folds of the mucous membrane lining the intestines of various fishes, Rathke[7] mentions crossfolds (Querfalten) and ringfolds (Ringfalten) as occurring in *Clupea alosa*, the grayling (*Thymallus*), whitefish (*Coregonus*), and *Salmo trutta*. While Rathke evidently was aware of the presence of these folds, it is clear that he did not interpret them as spiral valves, for he does not use the term "Spiralfalten" in this connection as he does in describing the spiral valve of the Sturgeon. The more exact meaning of the term "vestige" still remains to be determined; but at present such a discussion seems to be extraneous. As a matter of fact, however, the writers have found that in some specimens of "Rainbow" trout (*Salmo* sp.) there were six or seven well-developed spiral folds in the posterior end of the intestine which will be discussed more fully in a future paper.

Of the remaining Teleosts in which there are so-called rudiments or vestiges of spiral valves, *Gymnarchus*[8] apparently possesses a slight spiral valve which disappears 43 days after hatching. However, according to Cuvier and Valenciennes,[9] there is a well-developed spiral valve in *Chirocentrus*, one of the *Physostomi*. It is described as follows: "Upon opening the intestine, one finds a mucous lining very remarkable for its exceedingly numerous and close-set folds, which, for the whole extent of the canal, form a series of connivant valves, or rather an internal lamina wound in a very compact spiral—*une lame sur une spirale tres-serée*....." The description is supplemented by a drawing which differs from other drawings[10] of the spiral valve of *Chirocentrus*. However, it is apparent that *Chiro-*

[6] PARKER and HASWELL, *A Text-Book of Zoology*, 2: 218. 1897.

[7] HEINRICH RATHKE, *Uber den Darmkanal und die Zeugungsorgane der Fische*, 62–65, 83. 1824.

[8] R. ASSHETON, *The Development of Gymnarchus niloticus*. The Work of John Samuel Budgett. Edited by J. Graham Verr. P. 326.

[9] CUVIER and VALENCIENNES, *Histoire Naturelle des Poissons*, 19: 117; also Pl. 565 between pp. 312–313. 1846.

[10] E. S. GOODRICH, *A Treatise on Zoology*, fig. 77A. Edited by Sir Ray Lankester.

centrus hitherto has been the only Teleost known in which there is a true spiral valve in the adult.

The stomach of *Argentina silus* is siphon-shaped, somewhat like that of a salmon, although the posterior end-curve is conical, suggesting a short caecum. The pyloric limb is the shorter, being about half the length of the cardiac limb.

The duodenum, as it extends forward, curves downward and then upward. It then passes to one side of the stomach near the median line. In the specimen from which the drawing was made (Fig. 1), there were twenty-five pyloric caeca. Just posterior to the stomach, the intestine bends sharply upward and transversely, then backward, after which it runs in a straight line to the anal opening. This part of the intestine is occupied by a well-developed, though simply constructed, spiral valve (Fig. 1*A*). The exterior shows eighteen or twenty transverse septa on a little over two-thirds the length of the straight part of the intestine, but there are several incomplete whorls at the anterior end and a few closely folded ones at the posterior end which do not show externally. Back of the spiral valve, the intestine is a straight tube.

A specimen[11] of young *Argentina silus* 49 mm. long shows a well-developed spiral valve.

The air bladder is thick-walled and silvery, with a small aperture in the posterior end which suggests a pneumatic duct connection but which could not be traced.

SOME SKELETAL CHARACTERISTICS

Cranium.—The most prominent feature in a dorsal view of the cranium is the large frontal bones which extend backward above the eyes and nearly to the posterior margin of the cranium, almost completely covering the parietals. The frontals overlap each other and they are so closely bound together that it is difficult to separate them. When they are removed, the thin and rather narrow parietals are seen lapped underneath these bones. The parietals overlap each other widely and also cover the supraoccipital except for the supraoccipital crest and a narrow posterior margin. The supraoccipital bone is extended foreward into a tongue-shaped process upon which the parietals rest. This process is connected by a cartilaginous bridge

[11] In the collection of Mr. W. W. Welsh, U. S. Bureau of Fisheries. Grampus station 10027. August 14, 1912.

to the sphenotic bones on each side and a narrower ridge extends upward on the inner side of the alisphenoid. There is a cartilage extending downward between parts of the opisthotic[12] and epiotic bones.

The parietals extend laterally and cover the large pit on either side which is bounded by the opisthotics, pterotics, and epiotics. This pit is filled ordinarily by the foreward extension of the large lateral muscles of the body. In *Salmo*, this pit is bounded by the same bones as in *Argentina*, but it is not covered over by the parietals. In *Osmerus*, the pit is bounded by the pterotic and epiotic, the parietals not covering it. Neither do the parietals in *Osmerus* meet in front of the supraoccipital.

The preoperculum falls almost perpendicularly from its fascet. Its two limbs form nearly a right angle, the lower limb which extends forward being as long as the upper, and both are connected at the angle by a heavy flange which is roughly quadrate in outline. The metapterygoids are much reduced. The large mesopterygoids extend downward between the metapterygoids and quadrate bones.

The symplectic extends from the hyomandibular diagonally downward to the top of the lower limb of the preopercle and thence forward. A part of the quadrate bone extends backward on top of the lower limb of the preopercle and overlaps the forward extension of the symplectic. The whole apparatus has the appearance of being drawn downward and forward. There are no teeth on the mesopterygoids,[13] maxillaries, or premaxillaries, but there are small, sharp teeth in single rows on the anterior margin of the vomer and palatines, and a few on the tongue. The preorbital and three suborbital bones extend from the premaxillary backward across the cheek. There is no supplementary maxillary. The premaxillaries are securely fastened to the vomer by connective tissue which makes these bones immovable.

The upper margin of the bones of the lower jaw is strongly arched, the apex of the arch being at the overlapping of the dentary and articular bones. The anterior margin of the dentary is concave and toothless, but it is hard and chisel-edged. Between the dentary and articular bones is a splenial bone, which lies on top of the Meckel's car-

[12] Regan did not recognize the existence of the opisthotic bone in the skull of *Argentina*. It may be seen to best advantage after the frontals and parietals are removed.

[13] There are teeth on the mesopterygoids of *Osmerus*.

tilage. The upper and outer surface of this bone forms a broad contact with the inner surface of the articular. The articular is heavily reenforced on the inner surface at its articulation with the quadrate. The angular bone is present.

Vertebrae.—There are thirty-six abdominal and thirty caudal vertebrae in the vertebral column of our specimens of *Argentina silus.*[14] In the first twenty-one abdominal vertebrae, the neurapophyses are not fused into neural spines and the neural canal is not closed above in the first twenty. The neural canal is closed in the twenty-first, but there are still two neural spines. The parapophyses of the abdominal vertebrae extend outward as rather broad, rhomboidal platforms which lie nearly horizontal, the ribs being attached to the outer corners. The parapophyses become progressively narrower posteriorly and gradually merge into the haemapophyses of the caudal vertebrae. There are ribs on all but the last three abdominal parapophyses. In *Salmo*, the first two abdominal vertebrae do not bear ribs.

Epipleurals are borne on at least twenty-six of the abdominal vertebrae. These bones are ankylosed with the neural spines and may not be separated from them without breaking them apart. The neurapophyses of these vertebrae are articulated loosely to the centra and each may be lifted off of the centrum with the attached zygapophysis and epineural. In those vertebrae which do not bear epineurals, the neurapophyses are ankylosed with the centrum. None of the epipleurals of *Salmo* or *Osmerus* are ankylosed with the neurapophyses.

In the caudal vertebrae, the haemal arch is closed, but in the first nine, the haemapophyses extend downward separately, but they are bridged across by an arch instead of a solid, straight-edged connection, as in *Salmo*. They increase in length posteriorly and taper inward toward each other until, in the tenth, there is a single haemal spine. The 45th vertebra is shown in figure 2, *E*. The last undoubted vertebra is much like that of *Osmerus*. The caudal stylus is composed of elements extending from the upper and lower sides of the centrum whose axis is directed slightly upward. The upper element of the stylus is the heavier, while the reverse is true in *Osmerus*. However, there are three rather indistinct vertebrae whose axes are directed

[14] The following numbers of vertebrae in *Argentina silus* are recorded in various ichthyological works: Day, 65; Smitt, 65-68; A. Schubberg, 66.

upward posterior to the stylus, while in *Osmerus* this is not the case. (Fig. 2, *D*.)

Pelvic Bones.—The pelvic bones differ widely from those of other Isospondyli. There is one distal pterygiophore loosely articulated to the basipterygium. Above it, there is a large, spheroidal swelling of hard bone excavated on the inner side to which the first ray is articulated. From this spheroidal swelling, a slender shaft projects

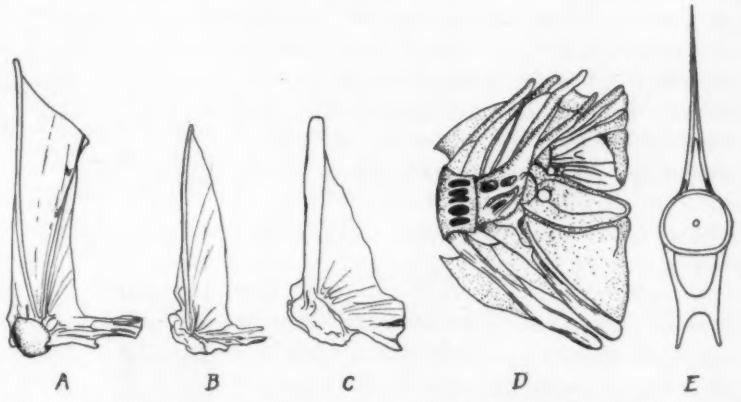

Fig. 2. *A*, basipterigium of *Argentina silus*, × 1½; *B*, basipterigium of *Osmenus mordax*, × 3; *C*, basipterygium of *Salmo sebago*, × 2; *D*, caudal vertebrae of *Argentina silus*, × 2; *E*, 45th vertebrae of *Argentina silus*, showing the arched connection between the haemopophyses, × 2.

forward along the margin and another shaft, originating at the base of the first, runs diagonally forward across the basipterygium. The anterior margin of the basipterygium extends diagonally across the ends of the two shafts, the whole bone being trapezoidal in shape, as shown in figure 2, *A*. In this respect, it differs from the basipterygia of other Isospondyli which are roughly triangular in outline. (Fig. 2, *B*, *C*.) A lateral process extends inward to meet a similar process on the opposite side.

Pectoral Girdle.—There is no postclavical such as that found in a salmonid. The actinosts are thin, but they are connected by webs of bone. The mesocoracoid is present and well developed. The supratemporal is a thin, blade-shaped bone loosely attached to the upper posterior margin of the supraoccipital. Of the two processes of the posttemporal bone, the lower which curves downward is the

longer. It is firmly attached to the base of the exoccipital by tough connective tissue.

The pectoral girdle is further attached to the skull and vertebrae by three rod-like ligaments on each side. The upper ligament passes from the posttemporal to the basioccipital. The second is attached to the supraclavical and the first vertebra which is ankylosed with the skull. The third ligament attaches the clavical to the second vertebra, or the first which is not ankylosed with the skull.

Scales.—The scales of *Argentina silus* differ greatly from those of *Osmeridae* or *Salmonidae*. In these two families; the scales are smooth and cycloid, but in *Argentina silus* they are roughened by small spines, and they are ctenoid in a manner similar to certain clupeids and percids (Menhaden and *Stizostedion*). The heart-shaped scales as described by Smitt appear only along the lateral line.

SUMMARY OF CHARACTERISTICS OF *Argentinidae* AS INDICATED BY *Argentina silus*

Visceral characteristics

Stomach bluntly caecal; intestine *with well-developed spiral valve;* pyloric caeca much less numerous than in *Coregonidae*, not much less numerous than in *Salmonidae*, and much more numerous than in *Osmeridae;* air bladder thick and silvery; pneumatic duct, if any, connected with its posterior end.

Skeletal characteristics

Cranium:—Frontals extend backward overlapping parietals, nearly covering them. Parietals overlapping on top of supraoccipital; opisthotic present; splenial bone present in lower jaw; mesopterygoids and jaws toothless; no supplementary maxillary.

Vertebrae:—66 all told. Double neural spines in first 21, canal being open in first 20. Ribs on all but last three abdominal vertebrae. Osseous epipleurals on at least 26 abdominal vertebrae; these are ankylosed to zygapophyses and neural spines; haemapophyses of abdominal vertebrae bridged by arch instead of straight-edged piece as in *Salmo;* pelvic bones with trapezoidal instead of a triangular basipterygium.

Pectoral girdle:—With no postclavical process and with thin actinosts which are connected by webs of thin bone.

Scales:—Ctenoid. Modified along lateral line.

SYNOPSIS AND REVIEW OF THE HISTORY OF THE CLASSIFICATION OF *Argentina*

The statement by Linnaeus that there are teeth on the jaws and tongue[15] ("*Dentes* in maxillis, lingua") is not borne out by Artedi[16] to whom Linnaeus refers, or by subsequent descriptions. Artedi says teeth on tongue and palate ("*Dentes* in lingua & Palate"). Furthermore, Linnaeus states the branchiostegal rays as 8. Artedi does not mention the number but all subsequent descriptions state them as 6. While Linnaeus does not mention the number of pyloric caeca it is interesting to note that Artedi says that there are 6 or 7. Both of the foregoing refer to the Mediterranean species *Argentina sphyraena.*

In their discussion of the genus *Argentina,* Cuvier and Valenciennes indefinitely mention numerous caecal appendages[17] and state that the stomach ends in a cul-de-sac. The genus is included in "Salmonoides." Gunther[18] says: Pyloric appendages in moderate numbers. He refers the family to *Salmonidae,* which includes *Salmo, Oncorhynchus, Brachymystax, Luciotrutta, Plecoglossus, Osmerus, Thaleichthys, Hypomesus, Mallotus, Retropinna, Coregonus, Thymallus, Argentina,* and *Microstoma* comprised in the first group Salmonina, in the order named.

In recognizing the subfamily *Argentininae* of Bonaparte, Gill states that it differs from *Salmoninae* by the stomach ending in a blind sac posteriorly. In this he agrees with Cuvier and Valenciennes. Gill's original observations, however, were apparently on the smelts and allied forms. In the subfamily he recognized two genera, *Argentina* and *Silus,* the first with cycloid, the other with spinigerous scales. Later Gill placed the subfamily *Argentininae,* comprising *Mallotus, Osmerus* and *Microstoma,* also by implication, other Osmerids and *Argentina,* in the family *Microstomidae.*[19] Ten years later, however, Jordan and Gilbert include *Argentina* in the family *Salmonidae,* recognizing no subfamilies in the description of the genus, thus following Gunther.

[15] *Systema Natura:* 315. 1758.

[16] *Ichthyologia,* **5**: 8. 1738.

[17] *Histoire Naturelle des Poissons,* **21**: 299. 1898.

[18] *Catalogue of the Physostomi, British Museum,* p. 202. 1866.

[19] *Catalogue of the Fishes of the East Coast of North America.* Smith. Misc. Coll. **1873**: 11–32.

Without stating any additional characters, Gill, in 1884, established the family *Argentinidae*.[20] By inference the family distinction is that of the caecal stomach.

Smitt[21] retains *Argentina*, as well as the Osmerids, etc., in *Salmonidae*. In his diagnosis of the genus, no character of more than generic value is mentioned. In expressing the relationship of *Argentina* to other forms, however, he says that the odor and few pyloric appendages point to the Smelt and the stiff but fragile fin rays and the singular shape of the scales are reminders of the Scopelids. Also that the peculiarity of the scales suggests the extinct genus *Osmeroides*, which, however, in its numerous branchiostegals and dentition was more like the salmon. Jordan and Evermann accept *Argentinidae*, of Gill, comprising the Osmerids, etc., as well. Their characterization is largely composed of the generic characters of the Osmerids. They state that the stomach is a blind sac, and the pyloric caeca few or none. Following the family diagnosis, the statement is made that there are about ten genera and perhaps a dozen species which are reduced *Salmonidae* smaller and in every way feebler than the trout, but similar to them in all respects except in the form of the stomach.

More recently Regan separated the Osmerids from the *Argentinidae* making for them the family *Osmeridae*, the latter differing from the *Argentinidae* in having toothed mesopterygoids. Both the *Argentinidae* and *Osmeridae* he supposed to differ from the *Salmonidae* in the absence of opisthotics and upturned vertebrae at the posterior end of the vertebral column.

Unless the ensemble of previously designated generic characters of *Argentina* is considered of family rank, no one prior to Regan has enunciated a valid family character, and even he was mistaken concerning the absence of the opisthotic in *Argentina*. However, its presence in *Argentina* and absence from the Osmerids strengthen the family rank of the latter. The fact that *Argentina* possesses opisthotics and vestigial or rudimentary upturned vertebrae, as previously indicated, might be construed by some to show that the genus represents an intermediate between the Osmerids and Coregonids, and even the shape of the stomach as represented by our specimens of *Argentina silus* would support this view. However, there are

[20] Annual Report of the Board of Regents of the Smithsonian Institution for the year 1884 (1885), p. 619.

[21] *Scandinavian Fishes*, 2: 912. 1895.

other characters in which they diverge but in which they should intergrade if they represent true intermediates in a direct line of development. Most of the characters, as well as those mentioned by Smitt and others enumerated in the classifications of *Argentina*, show resemblances merely, rather than actual indications of relationship. And those resemblances represent some of the Salmonoid tendencies of characters possessed by the generalized ancestral form, *Argentina* being a highly specialized terminal product of an early divergent. The fact that it is a comparatively deep water group, of apparently wide distribution, possessing an intestinal spiral valve, considered together with its general structure, would support this view.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. The abstracts should conform in length and general style to those appearing in this issue.

GEOLOGY.—*The New Salem lignite field, Morton County, North Dakota.* EUGENE T. HANCOCK. U. S. Geol. Surv. Bull. **726-A.** Pp. 39. 1921.

The New Salem field is part of the great lignite region of western North Dakota and adjacent regions. The history, commercial geography, and surface features of the area are summarized in two pages. Six pages are given to the discussion of the geologic section which includes the Lance and Fort Union formations. Within the Lance is the Cannonball marine member which has been the subject of much recent discussion and is named from the Cannonball River traversing this field. One bed of lignite was found in the Lance below the Cannonball member, but the valuable beds are confined to the upper 200 to 300 feet of the Fort Union.

The beds in most of this field have a very gentle dip (5 to 10 feet to the mile) toward the northwest, with minor folds; in the northwest part of the field they form a gentle syncline. About three pages are given to physical and chemical data and graphic sections of the coal in considerable detail. The heating value ranges about 6,000 to 7,000 calories for coal as mined. Fourteen pages are devoted to a description by townships of the occurrence of the coal in the seventeen townships examined.

MARCUS J. GOLDMAN.

GEOLOGY.—*Ground water in the Southington-Granby Area, Connecticut.* HAROLD S. PALMER. U. S. Geol. Surv. Water-Supply Paper **466.** Pp. 213. 1921.

This paper is the fourth to appear of a series of detailed reports on the ground-water resources of selected areas in Connecticut. The first part is of a general character and treats of the water-bearing formations, occurrence and recovery of ground water, and its quality. This is followed by descriptions of the eighteen towns included in the area, which is partly in the Central Lowland and partly in the Western Highland of Connecticut.

Almost everywhere water may be obtained in small quantities from fissures and joints in the bed rocks which include crystalline rocks of pre-Triassic age and sandstone, shale, and trap of Triassic age. The till that mantles the bed rock of the hills and upper valley slopes yields in general satisfactory domestic supplies. The stratified drift or glacial outwash deposits of the lowlands yield abundant supplies of water except in the more unfavorable topographic situations.

Maps show the distribution of the water-bearing formations, the distribution of woodlands, and the locations of the wells and springs referred to in the tables in the text.

HYDROLOGY.—*Ground water for irrigation near Gage, Ellis County, Oklahoma.* DAVID G. THOMPSON. U. S. Geol. Surv. Water-Supply Paper **500-B.** Pp. 21. 1921.

This paper contains a brief description of the geology and occurrence of ground water in a part of Ellis County in western Oklahoma. The region is in the semi-arid belt and in years when the precipitation is deficient crops may fail. In August, 1918, in a well that was being drilled for oil near Gage a large flow of artesian water was struck, which it was hoped could be used for irrigation. Investigation showed that the water comes from the Permian "Red Beds" and, although in sufficient quantity, it is generally so highly mineralized that it cannot be used for irrigation. Water of good quality can be obtained from the Tertiary rocks, but these rocks do not yield enough water to provide for irrigation. The conclusion is reached that water can be obtained for irrigation only along the floodplains of the larger streams in the area. D. G. T.

ORNITHOLOGY.—*Mutanda ornithologica. IX.* H. C. OBERHOLSER. Proc. Biol. Soc. Wash. **33:** 83–84. 1920.

Preoccupied names of five species of birds cause the following nomenclatural changes. The bird commonly known as *Dendrocitta sinensis* (Latham) is renamed *D. celadina*. The name of the wagtail now called *Motacilla longicauda* Rüppell is changed to *M. rhadinura*. The South African warbler, *Eremomela flaviventris* (Burchell), is hereafter to be called *E. griseoflava perimacha*. The Indian babbling thrush that has long been known as *Crateropus griseus* (Gmelin) is renamed *Turdoides polioplocamus*, since in addition to the preoccupation of its specific name, the generic name *Turdoides* Cretzschmar must supersede *Crateropus* Swainson. Furthermore, *Arrenga cyanea* (Horsfield) will henceforth be known as *A. glaucina* (Temminck). H. C. O.

ORNITHOLOGY.—*Unusual types of apparent geographic variation in color and of individual variation in size exhibited by* Ostinops decumanus. F. M. CHAPMAN. Proc. Biol. Soc. Wash. **33:** 25–32. 1920.

Study of *Ostinops decumanus* shows that there are great individual differences in size apparently attributable to age, and this involves a remarkable variation not only in the length but in the shape of the wing chiefly in males. Furthermore, an interesting geographic color variation in which there appear wholly or partly yellow feathers scattered throughout the plumage of the body and wing coverts indicates an undescribed race in Bolivia, which is described as *Ostinops decumanus maculosus*. H. C. OBERHOLSER.

ORNITHOLOGY.—*Food habits of seven species of American shoal-water ducks.* DOUGLASS C. MABBOTT. Bull. U. S. Dept. Agric. **862.** Pp. 67, pls. 7. 1920.

The food of *Chaulelasmus streperus* to a large extent consists of leaves and stems of water plants, and, with the exception of that of *Mareca americana*, includes a larger percentage of vegetable matter than any other species. The food of *Mareca americana* is almost the same as that of the previous species. As many as 64000 seeds of the spike rush (*Eleocharis*) have been noted in a single stomach. The diet of *Mareca penelope* and *Nettion carolinense* is made up principally of water plants and their seeds.

The blue-winged teal (*Querquedula discors*) feeds to a large extent on the seeds and other parts of water plants, although nearly one-third of its food is animal matter, mostly mollusks, insects, and crustaceans. The food of *Querquedula cyanoptera* is very similar.

Vegetable matter comprises about seven-eighths of the diet of *Dafila acuta tzitzihoa*, and this is chiefly seeds and other parts of plants, principally those growing in or near water. Individual birds have been known to consume for a single meal 28000 seeds of *Salicornia ambigua*. The remaining portion of the food of this duck consists of animal matter, such as mollusks, crustaceans, and insects.

The well-known *Aix sponsa* feeds mostly on the seeds and other parts of water plants, on acorns, grapes, berries, and the seeds of trees and shrubs. From a single stomach 10000 seeds of lizard's tail (*Saururus cernuus*) have been taken. About one-tenth of its diet is animal matter, chiefly insects and spiders.

In all, 2888 stomachs of the seven species have been examined, and the various items of food identified in each species are shown in an extended table which closes this bulletin. HARRY C. OBERHOLSER.

ORNITHOLOGY.—*Records of several rare birds from near Washington, D. C.* B. H. SWALES. Proc. Biol. Soc. Wash. **33:** 181–182. 1920.

The following interesting birds are here recorded from the region about Washington, D. C., all except one from specimens obtained: *Colymbus holboellii, Oceanites oceanicus, Phalaropus fulicarius, Numenius americanus, Pluvialis dominica dominica, Coragyps urubu urubu,* and *Aquila chrysaetos.* H. C. OBERHOLSER.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

PHILOSOPHICAL SOCIETY

856TH MEETING

The 856th meeting of the Philosophical Society of Washington was held in the Cosmos Club auditorium, Nov. 19, 1921. It was called to order at 8:20 p.m. by President FARIS with 49 persons present.

The first paper of the evening, on *Dip-needle errors arising from minute pivot defects*, was presented by Mr. H. W. FISK, and was illustrated. It was discussed by Messrs. L. A. BAUER and L. J. BRIGGS.

After all compensating reversals of instrument and needle have been made in determining the magnetic inclination or dip, with a dip circle, there will

be outstanding characteristic differences between results obtained at the same station with two or more needles. These are probably due to irregularity of general form of pivot and are eliminated by applying corrections derived from least square reductions where data are available, or from empirical graphs otherwise.

Occasionally a needle will give a result differing widely from the mean of the others used at the same station, and a critical study of several cases of this kind derived from results of field work in widely separated regions, shows that when not purely accidental, these differences vary with the varying dip as they would if they were caused by a small particle adhering to the pivot of the needle. A method was presented of analyzing the results derived from a series of stations at each of which the dip had been obtained by use of four needles, so that such deviations from the normal value could be readily recognized. Cases illustrating the results of such analysis were presented.

Theory was developed by which it was shown that the occasional differences under investigation could be produced by a very minute particle of rust, and an equation was given by which the diameter and thickness of the particle could be determined. By this method it was found that a minute patch of rust 0.02 millimeter in diameter and 6×10^{-5} millimeters thick, on the pivot of an ordinary Dover dip needle, would produce an error of 6 minutes in arc in the determination of dip at a place where the total magnetic force is 0.55.

An example was given to show that the rust particle might later become detached so that the needle would behave normally at the value of dip. Also it was shown that particles of this kind develop very quickly. From these examples it is concluded that the correction for a dip needle cannot be relied upon permanently at any one place nor be safely transferred to a place where the field has a different direction or intensity without a comparison with such a reliable standard as is afforded by the latest type of portable earth inductor. In case a dip circle must be used, not less than four needles should be employed in order to furnish an improved mean, and to better detect such errors as arise from minute pivot defects. (Author's abstract.)

The second paper on *The latitude of Ukiah and the motion of the Pole* was presented by Mr. WALTER D. LAMBERT and was illustrated. It was discussed by Messrs. L. H. ADAMS and L. A. BAUER.

Prof. A. C. Lawson in support of his explanation of certain earth movements in California brings forward the evidence afforded by the astronomic latitudes at Ukiah, California, one of the stations of the International Latitude Service. These latitudes show an apparent increase of about 0.01 a year, which is explained as an actual shifting northward of the crust at Ukiah relative to its substratum. Ukiah is somewhat outside of the region in which the existence of large earth movements has been proved by the evidence of triangulation executed at different dates. The attempt is made in this paper to see whether the astronomical evidence at Ukiah may properly be interpreted otherwise than as indicating a creep of the surface strata.

It is found that the other stations of the International Latitude Service show increases or decreases of the same order of magnitude as that of Ukiah, the general tendency being toward an increase, a feature especially noticeable toward the end of the period of observation. At Gaithersburg, Maryland, the rate of increase even exceeds that at Ukiah. The universality of these

changes and their apparent dependence on the longitude of the station make it natural to seek an explanation in a displacement of the Earth's Pole toward those stations showing the most rapid increases. It is found that the observed rates of change may be satisfied within reasonable limits by a shifting of the North Pole toward the Equator along the meridian of 77° West of Greenwich at the rate of about 0.0050 second a year combined with a cumulative correction to the average declination of the stars used, a correction varying with the time as the program of stars varies. A brief discussion is given of the geophysical aspects of such a shifting of the Pole.

Certain incidental results of the investigation are also mentioned, in particular a rough confirmation of Helmert's work on the figure of the Earth and its moments of inertia as deduced from gravity observations. Even a rough confirmation is of value on account of the presence in the observed values of gravity of systematic influences due to local geological and topographic conditions, and also on account of the fact that good determinations of gravity are possible only on one-fourth of the earth's surface, that is, on land. The results on the moments of inertia, etc., as deduced from the observations of the International Latitude Service are subject to a correction, probably small but not yet precisely evaluated, for the mobility of the ocean waters. (Author's abstract.)

H. H. KIMBALL, *Recording Secretary.*

SCIENTIFIC NOTES AND NEWS

Mr. A. A. BAKER has been appointed geologic aid in the U. S. Geological Survey, and has been assigned to the Alaskan Division.

Mr. W. N. BRAMLETTE, assistant geologist of the U. S. Geological Survey, has been furloughed from the Survey for several months to take up work with the Department of Marine Biology of the Carnegie Institution of Washington.

Mr. DAVID I. BUSHNELL, JR., is preparing for the Bureau of Ethnology a short account of the Cahokia and other mounds in Illinois, near East St. Louis, Missouri. A unique feature of his report will be aero-photographs of the whole group, the first attempt to obtain bird's-eye views of North American prehistoric mounds from an aeroplane.

Mr. W. O. CLARK has resigned from the U. S. Geological Survey, effective January 1, to accept a position as water-supply geologist with a firm in Honolulu, Hawaiian Islands.

Dr. ARTHUR L. DAY, director of the Geophysical Laboratory, Carnegie Institution of Washington, gave an illustrated public lecture at the Institution on the evening of November 29, on *The eruption of Mount Lassen.*

Prof. CHARLES MOUREU of the College de France and president of the International Union of Pure and Applied Chemistry, and Prof. A. MAYER of the University of Strasbourg, are in Washington as chemical advisers to the French delegation to the Conference on Limitation of Armaments.

Mr. WILSON POPENOE, agricultural explorer for the U. S. Department of Agriculture, returned to Washington in November after a two years' absence in Guatemala, Costa Rica, Colombia, Ecuador, Peru, and Chile.

Mr. PAUL C. STANDLEY of the National Museum left Washington early in December for a botanical collecting trip to Central America under the auspices of the Museum, Harvard University, and the New York Botanical Garden. He will spend several months in Guatemala and Salvador.

Mr. R. W. STONE has been appointed assistant state geologist of Pennsylvania and has resigned from the U. S. Geological Survey, the resignation to be in effect January 1. His headquarters will be at Harrisburg, Pennsylvania.

Dr. GEORGE L. STREETER, director of the Department of Embryology of the Carnegie Institution of Washington, gave an illustrated public lecture at the Institution on the evening of November 22, on *Recent studies on the ear as an organ determining equilibrium.*

Dr. H. U. SVERDRUP, physicist of the Roald Amundsen Arctic Expedition, which recently completed the passage by water north of Siberia, is spending several months as research assistant at the Department of Terrestrial Magnetism, Carnegie Institution of Washington. He is taking part in reduction of magnetic observations already taken and also preparing for new series of magnetic, oceanographic, meteorological and other observations to be taken on the continued expedition across the north Polar Sea to be begun by the Amundsen party in the spring of 1922.

Secretary C. D. WALCOTT of the Smithsonian Institution has been elected a corresponding member of the Société Géologique de Belgique, of Liège, Belgium.

Mr. CHUNG YU WANG, consulting mining engineer and geologist, is one of the technical councilors with the Chinese delegation to the Conference on Limitation of Armaments.